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DAVID W. TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

Bethesda, Maryland 20084

CASDAC ARRANGEMENT SUBSYSTEM

EQUIPMENT ARRANGEMENT PROGRAM (EQARR)

FUNCTIONAL DESCRIPTION

by

MURLE C. HENDERSON

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Computation, Mathematics, and Logistics Department

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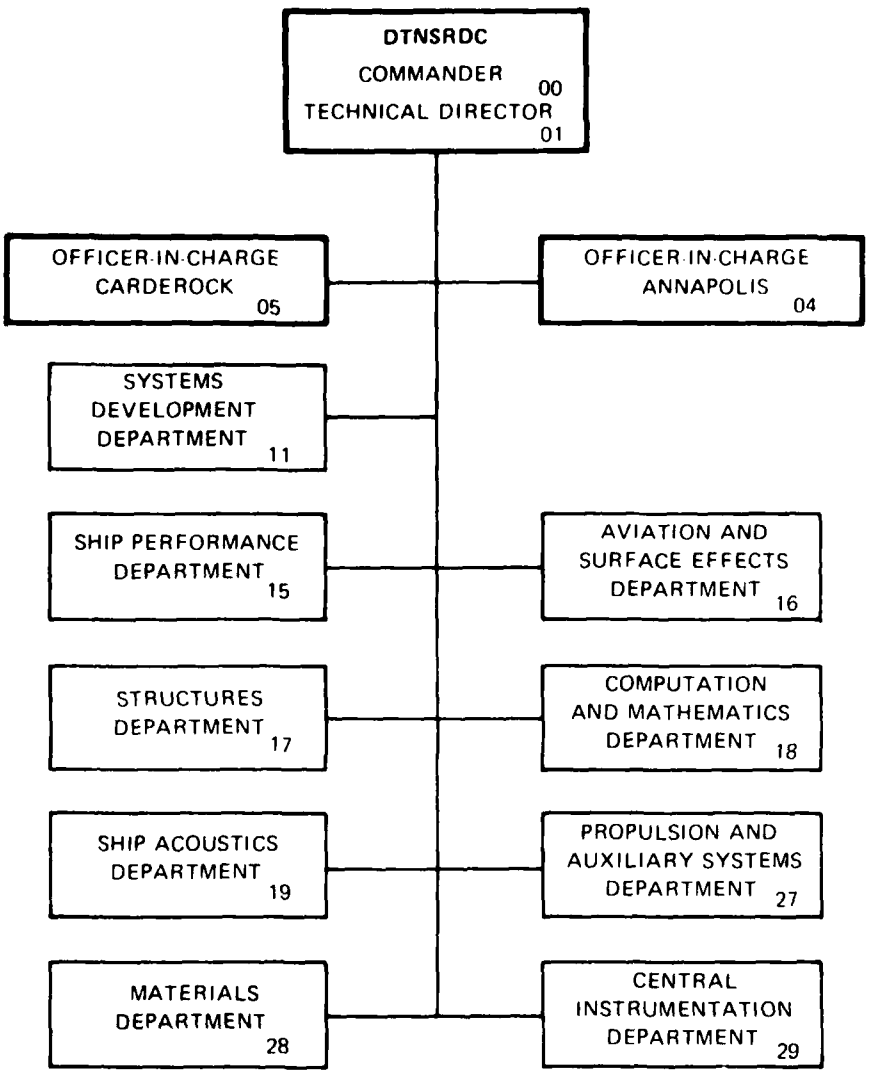

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This report documents the functional description for the interactive graphics program EQARR. It is intended to provide the description of the ship's equipment arrangement design functions to be accomplished by the program. Equipment arrangements are defined as the process of positioning equipment into predefined compartments of a ship with respect to their physical and functional interfaces.

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ABSTRACT

This functional description is written for the interactive graphics program EQARR, CASDAC Program Number 170073. It is intended to provide the description of the arrangement design functions to be accomplished by the program and serve as a basis for mutual understanding between the program developer and the users. EQARR, as a part of the CASDAC Arrangement Subsystem, will provide a tool for NAVSEA arrangement engineers to use in the development and modification of ship equipment arrangements in the conceptual, preliminary, and contract design phases of the ship acquisition process. Equipment arrangements are defined as the process of positioning equipment into predefined compartments of a ship with respect to their physical and functional interfaces. This functional description includes a preliminary design of the program information on performance requirements and descriptions of user impacts, and will serve as a basis for development of program tests.

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SECTION 1. GENERAL

1.1 Purpose

The Functional Description for the Equipment Arrangement Program (EQARR), CASDAC Program Number 170073, is written to provide:

a. The description of the arrangement design capabilities that the program will provide to serve as a basis for mutual understanding between the user and the developer.

b. Information on performance requirements, preliminary design of the computer program, and user impacts.

c. A basis for the development of program tests.

This functional description is a living document and will be revised and updated to reflect program design development.

1.2 References

a. Naval Sea Systems Command, CASDAC Arrangement Subsystem Functional Description, CASDAC Arrangement Subsystem Document No. A01FD, April 1979.

b. Naval Sea Systems Command, Computer Graphics Arrangement Program, CASDAC Program Number 233083.

c. Grosson, Joseph F. and Rakow, William O., "Development of Initial Program Estimates," Naval Engineers Journal, April 1975.

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SECTION 2. PROGRAM SUMMARY

2.1 Background

The Arrangement Subsystem of the CASDAC Hull Design System is an integrated set of computer programs for the arrangement engineers to use as a tool for ship arrangement design in the Conceptual, Preliminary, and Contract Design phases of the ship acquisition process. The Arrangement Subsystem as defined in reference (a) includes a computer program called the Equipment Arrangement Program (EQARR).

The ship equipment arrangement process positions the many and various equipments necessary for the ship to operate and perform its assigned mission. These equipments are positioned within predefined compartments for the shipboard function or to topside areas.

Within the Naval Sea Systems Command, the equipment arrangement process is performed by many different codes, each of which has cognizance of a particular technical discipline.

2.2 Objectives

The objective of the EQARR program is to develop a computer tool to be used by all the ship arrangement engineers to arrange equipment within a given general arrangement and store the equipment locations for use in producing drawings and providing information to other ship design disciplines.

2.3 Existing Methods and Procedures

Equipment arrangements is the process of positioning equipments of a subsystem with regard to their physical and functional relationships. The equipment arrangements process includes those ship design tasks known under a variety of terms such as topside arrangements, compartment layouts, space arrangements, and detail arrangements.

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The equipment arrangement process consists of the following steps:

a. Determine design requirements applicable to the particular subsystem.

b. Identify equipment required to achieve the design requirements and the description of each equipment.

c. Determine spaces allocated to the subsystem by the general arrangements.

d. Locate the equipment within the space assigned. This involves the unique criteria and methods applicable to each subsystem including design work study and installation requirements. Data such as outline dimensions (H x W x D), mounting requirements, service area and access requirements are used during the arrangement process.

e. Draw the equipment arrangement drawings consisting of plan, elevation, and section views.

f. Build models or mock-ups or prepare artist's view sketches, if required.

g. Prepare equipment data for inclusion in the Master Equipment List and as input to the weight, electrical, piping, ventilation, and access tasks.

h. Provide comments on the adequacy of the space allocation, including sketches of proposed changes.

i. Circulate drawings for comment.

j. In Contract Design, prepare specifications.

k. Adjudicate comments.

l. Analyze the equipment arrangements. This may involve techniques such as Design Work Study or construction of mock-ups.

m. Iterate through the above steps.

The Arrangement Subsystem addresses the entire process described above. The EQARR program deals only with step (d) of this process locating equipment within a space assigned by the ship's general arrangements.

This step typically consists of the following procedures:

a. Lift the dimensions of the cognizant compartments from the general arrangement drawings and redraw at the desired scale.

b. Make paper templates of the required equipment in the appropriate scale. This involves gathering dimensional and clearance data from reference documents.

c. Manipulate the templates on the drawing of the compartment boundaries. Usually, the equipments which are positioned first are those most constrained in location due to size, orientation requirements, ship services requirements, operator requirements, or interfaces with other compartments. These manipulations involve the unique requirements and constraints of each ship subsystem, a trial-and-error process until a feasible solution is found.

2.4 Proposed Methods and Procedures

Because of the unique criteria of each ship subsystem's equipment locations and the iterative nature of the equipment arrangement process, it is proposed to provide the engineer the capability to do the steps using an interactive graphics display and a computer rather than a pencil, drawing paper, and a calculator. The computer will then perform the necessary calculations and display the results for immediate review by the engineer.

The other steps of this process will be accomplished by other computer programs which interface through computer data bases with the EQARR program. For example, OUTFIT and CSPAR, which develop lists of required equipment and

GENARR, which develops the general arrangement, will interface with EQARR through computer data bases.

The EQARR program, from the engineer's viewpoint, will be very similar to the component branch of the Computer Graphics Arrangement (COGAP) Program, reference (b).

The following paragraphs describe more fully the procedure envisioned for using the EQARR program:

a. Upon logging on the computer system, the engineer will initiate execution of the EQARR program through a simple set of commands.

b. The engineer will identify his discipline, and the program will display a list of compartments which he has permission to arrange, rearrange, or only view.

c. The engineer can then select one of these compartments. Next, the program will display the current plan view arrangement of this compartment.

d. The program will then display a set of design options. These options are:

- Add an equipment to the arrangement.
- Modify an existing equipment.
- Delete an equipment from the arrangement.
- Display another view of the compartment.
- Move an existing equipment within the compartment.
- Rotate an existing equipment within the compartment.
- Display clearances and/or access requirements.
- Selective retrieval.

- Symmetry.
- Addition of Identical Components.

(1) If the "ADD" option is selected:

(a) The program will display a list of required equipment for the compartment. The user can then select one of these or enter the identifier or an equipment not on the list. If an item not on the list is desired, the engineer must also enter the SWBS group of the item.

(b) The program will then display a three-dimensional template of the equipment at the same scale as the compartment plan view being displayed.

(c) Next, the engineer positions the template by picking a location via the graphics terminal pointing device or entering coordinates. This is continued until the engineer is satisfied.

(d) The engineer then specifies a height above the deck for the equipment to be used when viewing a section or elevation view.

(e) The program then displays the "new" arrangement.

(2) If the "Modify" option is selected:

(a) The user indicates with a light pen the equipment (locker, storage area, etc.) to be modified.

(b) The user then can modify the equipment with the light pen or by entering new dimensions for the equipment via the keyboard.

(c) The equipment then will be placed as modified only in the current arrangement. The template(s) in the template catalog file will not be changed.

(3) If the "Delete" option is selected:

(a) The user indicates with the light pen the component to be deleted.

(b) The component then will be deleted from the current arrangement.

(4) If another view of the compartment is desired:

(a) The user types in via the keyboard the desired view (plan, elevation, or section; a depth scissoring capability is also available)

(b) The user also types in the desired viewing area (centerlines, dimensions, applicable boundaries, frame numbers, etc.) and whether the view, if other than a plan view, is to be looking from port, starboard, aft, or forward.

(c) The compartment and associated equipment will then be displayed in the desired view.

(5) If the "Move" option is selected:

(a) The user selects a component to be moved with the use of a light pen.

(b) The user then can relocate the component by moving the light pen to the desired locations or by typing in on the keyboard

the current and new coordinates of the selected component.

(c) The program then displays the new arrangement in the selected view.

(6) If the "Rotate" option is selected:

(a) The user indicates with a light pen the component to be rotated.

(b) The user then enters the desired rotation angle via the keyboard.

(c) The template will then be redrawn at the desired rotation.

(7) If component clearance and/or access requirements are desired (Only visual clearances and/or access requirements are intended. The program cannot be accessed to provide dimensions of clearances or access requirements.):

(a) The user types in applicable command(s) via the keyboard.

(b) Clearance and/or access requirements will then be shown as dashed lines.

(8) If selective retrieval is desired:

(a) The user types in applicable command(s) via the keyboard.

(b) The user then can select any of the following data items:

1. List Characteristic Names. Lists all names of characteristics currently

defined to the arrangement subsystem.

2. List Component Names. Lists all names of all components to which characteristic values have been assigned.

3. List Unit Names. Lists all currently defined standard and alternative unit names.

4. Display Component Description. Lists individual characteristics assigned to a given component.

5. Retrieve Components. Selectively retrieves components by values of characteristics.

6. Edit Short List. Allows the user to prepare or edit a short list of template names which can later be referred to in the arrangement division.

(c) The user then can return to normal procedure.

(9) If the symmetry capability is desired:

(a) The user types in applicable command(s) via the keyboard.

(b) The user then selects either the ship's centerline or other desired axis and locates one component.

(c) The program then displays this component and an identical component in symmetry about the

selected axis, i.e., port and starboard or aft and forward.

(10) If additional identical components in an arrangement are desired:

(a) The user types in, via the keyboard, applicable command(s) and desired quantity of identical components.

(b) The program then displays the selected quantity of identical components in the arrangement being worked by the user.

(c) The user then locates each of the identical components.

The program will have the capability to store all current arrangements and applicable previous arrangements so that the engineer can have them available for further arrangement studies.

2.5 Summary of Improvements

The primary deficiency of the manual process is the information management difficulty resulting from the iterative nature of the ship design process, the number of organizational entities involved, and the volume of data associated with ship arrangements. Following is a description of improvements accomplished with use of computer-aided design.

The development of the equipment arrangement for compartments and topside areas is not accomplished as a single-step, rigidly constrained, effort. This task is iterative by nature and changes many times during the normal course of a ship design. Use of the interactive graphics program EQARR interfaced with

the overall CASDAC system will greatly reduce the time required per iteration and thereby shorten the time span for a given ship design.

The program provides the mechanism to automatically load a digital description of a ship's equipment arrangements onto a digital data base. This data base can then be used through other computer programs to perform associated bookkeeping functions and prepare reports.

Time-consuming tasks such as draftsmen redrawing, updating, and producing revisions every time an arrangement change is studied will now be produced by a plotter and controlled digitally, thus reducing the need for manual drafting services. The drawings will adhere to drafting standards and will be uniform and legible. The designer may obtain an up-to-date drawing at any point during the design development by running the drafting program ARRDRFT. These features represent an improvement over the existing method of issuing drawings periodically during the design development and help insure that all involved disciplines are working with current information.

The design history (present arrangement and previous arrangements) will be stored on data files as the design develops. This capability will result in a more complete and accurate documentation of the design history which can be easily formatted and published.

Overall, the speed and interaction capability provided by the computer to load data and make changes should greatly increase the production output.

A summary of the improvements is as follows:

a. Reduced manpower per design iteration

b. Shortened time frame per design

c. Up-to-date arrangement information at user request

d. Standardized reports

e. Uniform drawings

f. Documented design history

g. Creation and maintenance of data catalogs which remain for use on later designs

2.6 Summary of Impacts

The primary impact of using the EQARR program is the required computer hardware needed by the program to effectively operate. The current NAVSEA inventory should be updated in order to more ably support the present arrangement design work. In addition, the graphics displays must be located within the arrangement design codes rather than in a segregated, remote computer room to facilitate user acceptance.

SECTION 3. DETAILED CHARACTERISTICS

3.1 Specific Performance Requirements

The EQARR program will be developed as a user-oriented modular and extendable computer program. User-oriented means that the program must be designed for the engineer who has little computer background and interacts with the engineer through the inputs and outputs in terms with which he is familiar. It must be extendable to allow additional capabilities to be added in the future.

The EQARR program will use the same three-dimensional equipment templates used by the COGAP program. In addition, the user should be able to construct new templates and/or modify existing templates. However, the template(s) in the template catalog file will not be changed. Also, EQARR will allow the user to construct partitions and "super templates" (a template consisting of more than one piece of equipment, for example, equipment racks, tables and chairs, etc.).

EQARR shall have the capability of using both fixed point coordinates and relative coordinates. A need for the use of relative coordinates arises when the arrangement engineer desires to relocate a multi-bay computer set or a multi-equipment rack. Instead of relocating each individual piece of equipment, any computer bay or piece of equipment in the rack that is relocated will automatically relocate all other associated equipment.

The EQARR program will use the Z coordinate of a component as well as the X and Y coordinates. This will allow the user to locate any component in any view and be assured of proper location in another view. This would result in components being positioned on the deck when in default orientation.

EQARR will have the capability to duplicate an existing arrangement.

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3.2 Program Functions

The objective of the EQARR program is to locate equipment within assigned spaces. This is accomplished with the following program functions:

a. Addition of an equipment to the arrangement.

b. Modification of existing equipment.

c. Deletion of an equipment from the arrangement.

d. Display of another view of the compartment.

e. Moving an existing equipment within the compartment.

f. Rotation of an existing equipment within the compartment.

g. Display of clearances and/or access requirements.

h. Selective retrieval.

i. Symmetry.

j. Addition of identical components.

The program will also have the capability to store the arrangement data on the Arrangement Subsystem data base.

3.3 Inputs/Outputs

The user inputs to the EQARR program consist of a terminal pointing device (light pen) or keyboard attached to the computer display to enter the following information:

- Program function to be performed.
- Applicable data or manipulation associated with a selected program function.

The user outputs of the EQARR program for the arrangement engineer are:

a. Information and directives/messages to the arrangement engineer.

b. Computer displays of the ship arrangement.

c. Menus of selectable program options.

d. Hard copy plot of the computer display at any point during use of the program.

3.4 Data Characteristics

As described in reference (a), the data base Arrangement Subsystem consists of three types of data files: ship arrangement data, catalog data, and working files. The ship arrangement data is maintained on a file called the Ship Arrangement File (SAF) which contains the latest official arrangement of the ship as defined by the general arrangement and equipment arrangement engineers using the Arrangement Subsystem computer programs to perform their cognizant arrangement design tasks.

Catalog files contain data which are independent of a particular ship such as descriptions of equipment, physical access requirements, etc.

Working files are copies of the SAF for use with the arrangement design computer programs to allow engineers to develop alternative solutions and proposals before selecting and approving one for incorporation into the SAF. A program module will be required to read the working file and update the changed data to the SAF. Access to this module will be such that only authorized personnel will be able to update the SAF.

EQARR uses the following data files:

a. Ship Arrangement File. The existing definition of the ship arrangement is provided by the SAF and the program updates this file with the program results if desired.

b. Working File. The Working File is a copy of the Ship Arrangement File which allows the engineer to develop

various alternatives. When an alternative solution is chosen, it is placed on the Ship Arrangement File.

c. Equipment Wireframe Template File. EQARR uses a catalog file of three-dimensional wireframe templates of equipment.

3.5 Failure Contingencies

The failure of the computer program to operate as desired can be caused by the following conditions and corrected by the noted actions:

a. Loss of executable program file and data files. The computer program is stored as a permanent file on the computer system. The loss of this file will require the program point of contact as noted in the user's manual to recreate the file from card backup.

b. Program execution error. If the computer program aborts while it is being executed, it will be necessary to restart the program once the cause of the failure is determined and corrected as follows:

(1) User input data error. Check the program user's manual for the proper data input procedures, correct the input data, and rerun the program.

(2) Program error. Contact the program point of contact as listed in the User's Manual and give him the input and output from the run. After correcting the program, he will inform the user.

c. Empty data files. Any program of the Arrangement Subsystem may be run in any sequence providing that the required input data are supplied. If the programs are run in normal sequence, most of this data will exist on the Ship Arrangement File. If these data have not been created, the user must manually create them.

SECTION 4. ENVIRONMENT

4.1 Equipment Environment

EQARR requires the following computer hardware in order to execute:

a. Cathode ray tube display with cursor and keyboard. This display will be used for interactive engineering of equipment arrangements.

b. Disk storage

c. Plotter (hard copy unit)

d. Card reader

e. Line printer

f. Storage tube. This display will be used for quick reference by engineers. An arrangement can be called up from the data base and displayed on the storage tube providing the engineer with easily accessible up-to-date information.

4.2 Support Software Environment

EQARR requires the following supporting computer software in order to execute:

a. FORTRAN IV compiler

b. Device-independent graphics routines (DIGRAF)

c. Random storage data management routines

4.3 Interfaces

In the Arrangement Subsystem, the interfacing of computer programs is done by the sharing of computer files. For example, if Program B required as input the results of Program A, this is done by Program A creating a computer file or portions of a computer data base which Program B can access to locate the information which it requires.

All of the ship-dependent data required as input to the EQARR program must be previously stored on the Ship Arrangement File. These ship-dependent data are created by the following Arrangement Subsystem Computer programs:

a. GENARR. The General Arrangement Program creates and modifies a general arrangement through the use of interactive graphics. The general arrangement stored by GENARR on the Ship Arrangement File includes the list of compartments on the ship, the location and geometry of each compartment, and the accesses of each compartment.

b. OUTFIT. The Outfit Requirements Program generates a list of required outfit and furnishings (SWBS group 6) for each compartment of a particular ship. This list for each compartment consists of the quantity, equipment identification, and SWBS group for each item of outfit and furnishings to be located in the compartment.

c. CSPAR. The CSPAR program generates a list of required combat system equipment (SWBS groups 4 and 7) for each compartment of a particular ship. The list for each compartment consists of the quantity, identifier, and SWBS group for each item of combat system equipment to be located in the compartment.

The equipment arrangement data stored on the Ship Arrangement File by EQARR are then used by the following computer programs:

a. ARRDRFT. The Arrangement Drafting Program is used to draw all of the arrangement drawings based on the definition of the general arrangement created by GENARR and the equipment arrangements created by EQARR.

b. EQRPT. The Equipment Report Program prints various equipment list reports.

c. EQACS. The Equipment Removal Analysis Program determines equipment removal routes. This program can provide inputs to the ship's Rapid Installation Plan (RIP).

4.4 Security

The security of the EQARR program includes the protection of the program from catastrophe, unauthorized use and tampering, and the protection of classified data or products.

The computer program is protected from catastrophe by storing copies of the program source card deck and documentation at several locations.

Tampering with the program file will be prevented by using the host computer system file protection features.

Unauthorized use of the computer program will be prevented by the use of computer system file protection features.

SECTION 5. COSTS

Cost estimates at this level of program definition must be based on parametric methods. In preparing cost estimates for EQARR, the methods described in reference (c) have been used to estimate program development costs. The program design phase for preparing a program specification has been estimated as 30% of the development cost.

TABLE 5-1 EQARR COST ESTIMATES

Item	Cost (in $1000's)
Specification	60
Coding	60
Testing	20
Documentation	30
Implementation	10
TOTAL	180

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SECTION 6. DEVELOPMENT PLAN

The development plan for EQARR program is presented in this section. No calendar dates of the program development schedule are shown; however, an estimate to accomplish each phase of the development is presented.

Each phase and its respective estimate to accomplish are as follows.

Phase	Estimate to Accomplish
Functional Description	3 man-months
Data Requirements Document	2 man-months
System/Subsystem Specification	See Note 1
Program Specification	4 man-months
Data Base Specification	See Note 1
Coding	12 man-months
Test Plan	0.5 man-months
Testing	5 man-months
Test Analysis Report	2 man-months
Users Manual	3 man-months
Computer Operation Manual	See Note 1
Program Maintenance Manual	3 man-months

Note 1: The EQARR program is only a part of the CASDAC Arrangement Subsystem; thus, these higher level specifications and manuals will be written for the entire CASDAC Arrangement Subsystem.

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